

## CLAIMS

What is claimed is:

1. A material unit transfer apparatus for moving at  
5 least one material unit between transport equipment and  
at least one material unit storage location, for use in  
an automated material handling system, the apparatus  
comprising:

a first substantially planar platform configured to  
10 hold at least two material units;

a first transfer mechanism operatively coupled to  
the first platform and configured to move one or more  
material units between the first platform and the  
transport equipment or the storage location along a first  
15 axis; and

a second transfer mechanism operatively coupled to  
the first platform and configured to move one or more  
material units between the first platform and a second  
substantially planar platform adjacent the first platform  
20 along a second axis, the second axis being disposed at  
substantially a right angle to the first axis.

2. The material unit transfer apparatus of claim 1  
wherein the first transfer mechanism includes at least  
25 one elongated member configured to translate in a  
direction parallel to the first axis for accessing one or  
more material units directly from the transport equipment  
or the storage location.

3. The material unit transfer apparatus of claim 2 wherein the first transfer mechanism further includes a first drive mechanism configured to drive the at least one elongated member while the elongated member  
5 translates in a direction parallel to the first axis.

4. The material unit transfer apparatus of claim 1 wherein the first transfer mechanism includes two elongated members operatively coupled to the first  
10 substantially planar platform near opposing edges of the first platform.

5. The material unit transfer apparatus of claim 4 wherein the two elongated members are configured to  
15 translate simultaneously in a direction parallel to the first axis for accessing one or more material units directly from the transport equipment or the storage location.

20 6. The material unit transfer apparatus of claim 4 wherein the first transfer mechanism further includes a first drive mechanism configured to drive the two elongated members while the elongated members translate in a direction parallel to the first axis.

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7. The material unit transfer apparatus of claim 1 wherein the second transfer mechanism includes at least one roller assembly.

8. The material unit transfer apparatus of claim 7 wherein the second transfer mechanism includes a plurality of roller assemblies, each roller assembly being configured to move a respective material unit  
5 between the first platform and the second platform in a direction parallel to the second axis.

9. The material unit transfer apparatus of claim 8 wherein the second platform is included in a second  
10 material unit transfer apparatus configured to move at least one material unit between the transport equipment and at least one material unit storage location.

10. The material unit transfer apparatus of claim 8  
15 wherein the plurality of roller assemblies is configured to move simultaneously the respective material units between the first and second platforms.

11. The material unit transfer apparatus of claim 10  
20 wherein the second platform is included in a second material unit transfer apparatus configured to move at least one material unit between the transport equipment and at least one material unit storage location.

12. The material unit transfer apparatus of claim 1  
25 further including a third transfer mechanism configured to lift one or more material units along a third axis disposed at substantially right angles to the first and second axes.

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13. The material unit transfer apparatus of claim 12 wherein the third transfer mechanism includes a plurality of lift assemblies, each lift assembly being configured to lift respective material units in a direction parallel to the third axis.

14. The material unit transfer apparatus of claim 1 wherein the material unit comprises a cassette pod.

15. The material unit transfer apparatus of claim 14 wherein the cassette pod comprises a front opening unified pod.

16. The material unit transfer apparatus of claim 1 wherein the transport equipment is selected from the group consisting of a conveyor and an overhead hoist transport vehicle.

17. The material unit transfer apparatus of claim 1 wherein the at least one material unit storage location is disposed in a storage unit selected from the group consisting of a stocker and a vertical carousel storage unit.

18. The material unit transfer apparatus of claim 1 wherein the at least one material unit storage location is disposed on one or more fixed shelves.

19. An automated material handling system, comprising:

one or more storage locations, each storage location being configured to hold at least one material unit;

transport equipment configured to move one or more material units between a plurality of predetermined  
5 sites; and

a material unit transfer assembly for moving one or more material units between the transport equipment and the one or more storage locations, the material unit transfer assembly including a plurality of material unit  
10 transfer apparatuses, each material unit transfer apparatus as recited in claim 1,

the plurality of material unit transfer apparatuses being arranged side-by-side within a plane defined by first and second orthogonal axes to allow a first  
15 transfer mechanism included in each apparatus to move along the first axis at least one material unit between the respective apparatus and at least one storage location or the transport equipment, and to allow a second transfer mechanism included in each apparatus to  
20 move along the second axis at least one material unit between the respective apparatus and an adjacent material unit transfer apparatus within the assembly.

20. The system of claim 19 wherein the first transfer  
25 mechanism of each material unit transfer apparatus includes at least one elongated member configured to translate along the first axis for accessing the at least one material unit directly from the storage location or the transport equipment, the material unit transfer  
30 assembly further including a common drive mechanism

configured for simultaneously driving the at least one elongated member of the respective material unit transfer apparatus.

5     21. The system of claim 19 wherein the material unit comprises a cassette pod.

22. The system of claim 21 wherein the cassette pod comprises a front opening unified pod.

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23. The system of claim 19 wherein the transport equipment is selected from the group consisting of a conveyor and an overhead hoist transport vehicle.

15     24. The system of claim 19 wherein the one or more material unit storage locations are disposed in a storage unit selected from the group consisting of a stocker and a vertical carousel storage unit.

20     25. The system of claim 19 wherein the one or more material unit storage locations are disposed on one or more fixed shelves.

25     26. The system of claim 19 wherein the transport equipment and each material unit transfer apparatus has at least one location associated therewith for holding at least one material unit, and further including

30             a plurality of sensors configured to detect the presence of respective material units in each storage location and in each location associated with the

transport equipment and the material unit transfer apparatuses, and to provide signals indicative of whether a respective material unit is present in each of the locations, and

5           a controller operative to receive the signals provided by the sensors and to control the movement of the material units based on the received sensor signals.

27. The system of claim 26 wherein the controller is  
10 further operative to maintain a database indicating whether a respective material unit is present in each storage location and in each location associated with the transport equipment and the material unit transfer apparatuses.

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28. A method of operating a material unit transfer apparatus for moving at least one material unit between transport equipment and at least one material unit storage location, for use in conjunction with an  
20 automated material handling system, comprising the steps of:

moving one or more material units between a first substantially planar platform and the transport equipment or the storage location along a first axis by a first  
25 transfer mechanism, the first platform and the first transfer mechanism being included in the material unit transfer apparatus; and

moving one or more material units between the first platform and a second substantially planar platform  
30 adjacent the first platform along a second axis by a

second transfer mechanism included in the material unit transfer apparatus, the second axis being disposed at substantially a right angle to the first axis.

5     29. The method of claim 28 wherein the first moving step includes translating at least one elongated member along the first axis for accessing the one or more material units directly from the transport equipment or the storage location, the elongated member being included in  
10    the first transfer mechanism.

30. The method of claim 29 wherein the first moving step further includes driving the at least one elongated member while the elongated member translates along the  
15    first axis by a first drive mechanism included in the first transfer mechanism.

31. The method of claim 28 wherein the first moving step includes translating simultaneously two elongated members  
20    in a direction parallel to the first axis for accessing the one or more material units directly from the transport equipment or the storage location, the two elongated members being included in the first transfer mechanism.

25     32. The method of claim 31 wherein the first moving step includes driving the two elongated members while the elongated members translate in a direction parallel to the first axis by a first drive mechanism included in the  
30    first transfer mechanism.



33. The method of claim 28 wherein the second moving step includes moving one or more material units between the first platform and the second platform in a direction  
5 parallel to the second axis by at least one roller assembly included in the second transfer mechanism.

34. The method of claim 33 wherein the second platform is included in a second material unit transfer apparatus  
10 for moving at least one material unit between the transport equipment and at least one material unit storage location.

35. The method of claim 33 wherein the second moving  
15 step includes simultaneously moving respective material units between the first and second platforms by two roller assemblies included in the second transfer mechanism.

20 36. The method of claim 35 wherein the second platform is included in a second material unit transfer apparatus for moving at least one material unit between the transport equipment and at least one material unit storage location.

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37. The method of claim 28 further including the step of lifting one or more material units along a third axis disposed at substantially right angles to the first and second axes by a third transfer mechanism included in the  
30 material unit transfer apparatus.

38. The method of claim 37 wherein the lifting step includes lifting respective material units in a direction parallel to the third axis by a plurality of lift  
5 assemblies included in the third transfer mechanism.

39. The method of claim 28 wherein the first moving step includes extracting a plurality of material units simultaneously from the storage location for subsequent  
10 transfer to the first platform.

40. The method of claim 28 wherein the storage location includes first and second sub-locations, and wherein the first moving step includes extracting a first material  
15 unit from the first sub-location for subsequent transfer to a distal end of the first platform, the first sub-location being disposed between the first platform and the second sub-location.

20 41. The method of claim 28 wherein the storage location includes first and second sub-locations, and wherein the first moving step includes extracting a second material unit from the second sub-location for subsequent transfer to a proximal end of the first platform, the first sub-  
25 location being disposed between the first platform and the second sub-location.

42. The method of claim 28 wherein the first moving step includes moving a plurality of material units

simultaneously from the first platform to the transport equipment or the storage location.

43. The method of claim 28 wherein the storage location  
5 includes first and second sub-locations, and wherein the first moving step includes moving a first material unit from a distal end of the first platform to the first sub-location, the first sub-location being disposed between the first platform and the second sub-location.

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44. The method of claim 28 wherein the storage location includes first and second sub-locations, and wherein the first moving step includes moving a first material unit from a proximal end of the first platform to the first  
15 sub-location, the first sub-location being disposed between the first platform and the second sub-location.

45. The method of claim 28 wherein the storage location includes first and second sub-locations, and wherein the  
20 first moving step includes moving a second material unit from a proximal end of the first platform to the second sub-location, the first sub-location being disposed between the first platform and the second sub-location.

25 46. The method of claim 28 wherein the storage location includes first and second sub-locations, and wherein the first moving step includes moving a first material unit from the first sub-location to the second sub-location, the first sub-location being disposed between the first  
30 platform and the second sub-location.

47. The method of claim 28 wherein the storage location includes first and second sub-locations, and wherein the first moving step includes moving a second material unit  
5 from the second sub-location to the first sub-location, the first sub-location being disposed between the first platform and the second sub-location.

48. The method of claim 28 wherein the material unit  
10 comprises a cassette pod.

49. The method of claim 48 wherein the cassette pod comprises a front opening unified pod.

15 50. The method of claim 28 wherein the transport equipment is selected from the group consisting of a conveyor and an overhead hoist transport vehicle.

51. The method of claim 28 wherein the at least one  
20 material unit storage location is disposed in a storage unit selected from the group consisting of a stocker and a vertical carousel storage unit.

52. The method of claim 28 wherein the at least one  
25 material unit storage location is disposed on one or more fixed shelves.

53. A method of operating an automated material handling system, comprising the steps of:

providing one or more storage locations, each storage location for holding one or more material units;

providing transport equipment for moving one or more material units between a plurality of predetermined  
5 sites;

providing a material unit transfer assembly for moving one or more material units between the transport equipment and the one or more storage locations, the assembly including a plurality of material unit transfer  
10 apparatuses, each material unit transfer apparatus as recited in claim 1, the plurality of material unit transfer apparatuses being arranged side-by-side within a plane defined by first and second orthogonal axes;

moving one or more material units between a first  
15 material unit transfer apparatus and the transport equipment or the one or more storage locations along the first axis by a first transfer mechanism included in the first transfer apparatus; and

moving one or more material units between the first  
20 transfer apparatus and a second material unit transfer apparatus adjacent the first transfer apparatus within the assembly along the second axis by a second transfer mechanism included in the first transfer apparatus.

25 54. The method of claim 53 further including the step of moving one or more material units from the second material unit transfer apparatus to the transport equipment or one or more second storage locations in a direction parallel to the first axis by a first transfer  
30 mechanism included in the second transfer apparatus.

55. The method of claim 53 wherein the first moving step includes extracting one or more material units from one or more first storage locations along the first axis for  
5 subsequent transfer to a first substantially planar platform included in the first material unit transfer apparatus.

56. The method of claim 55 wherein the second moving  
10 step includes moving the one or more material units from the first platform of the first transfer apparatus to a second substantially planar platform included in the second material unit transfer apparatus adjacent the first transfer apparatus along the second axis.

15 57. The method of claim 56 further including the step of moving the one or more material units from the second platform of the second transfer apparatus to one or more second storage locations in a direction parallel to the  
20 first axis by a first transfer mechanism included in the second transfer apparatus.

58. The method of claim 53 wherein the material unit comprises a cassette pod.

25 59. The method of claim 58 wherein the cassette pod comprises a front opening unified pod.

60. The method of claim 53 wherein the transport equipment is selected from the group consisting of a conveyor and an overhead hoist transport vehicle.
- 5 61. The method of claim 53 wherein the at least one material unit storage location is disposed in a storage unit selected from the group consisting of a stocker and a vertical carousel storage unit.
- 10 62. The method of claim 53 wherein the at least one material unit storage location is disposed on one or more fixed shelves.
- 15 63. The method of claim 53 wherein the transport equipment and each material unit transfer apparatus has at least one location associated therewith for holding at least one material unit, and further including the steps of
- 20 detecting the presence of respective material units in each storage location and in each location associated with the transport equipment and the material unit transfer apparatuses by a plurality of sensors,
- 25 providing signals indicative of whether a respective material unit is present in each of the locations by the plurality of sensors,
- receiving the sensor signals by a controller, and
- controlling the movement of the material units based on the received sensor signals by the controller.

64. The method of claim 63 further including the step of  
maintaining a database indicating whether a respective  
material unit is present in each storage location and in  
each location associated with the transport equipment and  
5 the material unit transfer apparatuses by the controller.